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ASSESSMENT OF SITE PRODUCTIVITY IN DENSE LODGEPOLE PINE STANDS

by

L. A. Smithers

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Assessment of Site Productivity in Dense Lodgepole Pine Stands

Project K-74

by

L. A. SMITHERS*

INTRODUCTION

The difficulty of assessing the productive capacity of forest lands in terms of site quality is without doubt one of the most important problems being faced by forest research workers at the present time. Site classification studies of lodgepole pine *(Pinus contorta* var. *latifolia)* stands in the subalpine region of Alberta are further complicated by the unusual growth and development habits of this species.

Forest site quality is generally regarded as the sum total effect of a number of factors which influence forest growth capacity, including soil variation, moisture conditions and climatic factors. Past history of the site also plays an important role in the long-term trends of forest productivity. The combination and integration of these factors brings about an exceedingly complex relationship. Although in theory site quality can have reference only to an extremely small area because of its continually changing value, for practical purposes arbitrary limits are established to define a particular site condition which may be applicable to a working area.

In attempting to assess forest productivity, research workers have used both direct and indirect measures of site quality. In the former, measurements of the basic factors mentioned above have been employed; however, the resulting classifications have generally been so complex as to be of little practical value. By far the most common method of assessing site quality has been to use a measure of the forest productivity itself under controlled conditions. From this method the site index measurement of the dominant height at an index age has been developed. In order to obtain a true picture of site quality from the index, the effects of other variables such as age, density and stocking must be eliminated. The growth behaviour of most native Canadian species follows a well-defined pattern in which the heights of truly dominant trees are sufficiently free from the effects of density to permit their use as a site index.

In contrast with other native Canadian species, lodgepole pine stands in Alberta show a most variable pattern of growth. Origin of stands of this forest type usually dates from fire, or from logging followed by fire. The number of seedlings which germinate and become established following these disturbances varies widely. Although the factors governing the seedling germination and establishment are not completely understood, it appears safe to say that many of these factors are not directly associated with site quality. To further complicate the picture, heavily stocked pine stands have a definite tendency to stagnate at an early age. Under these circumstances the individual trees show a very limited

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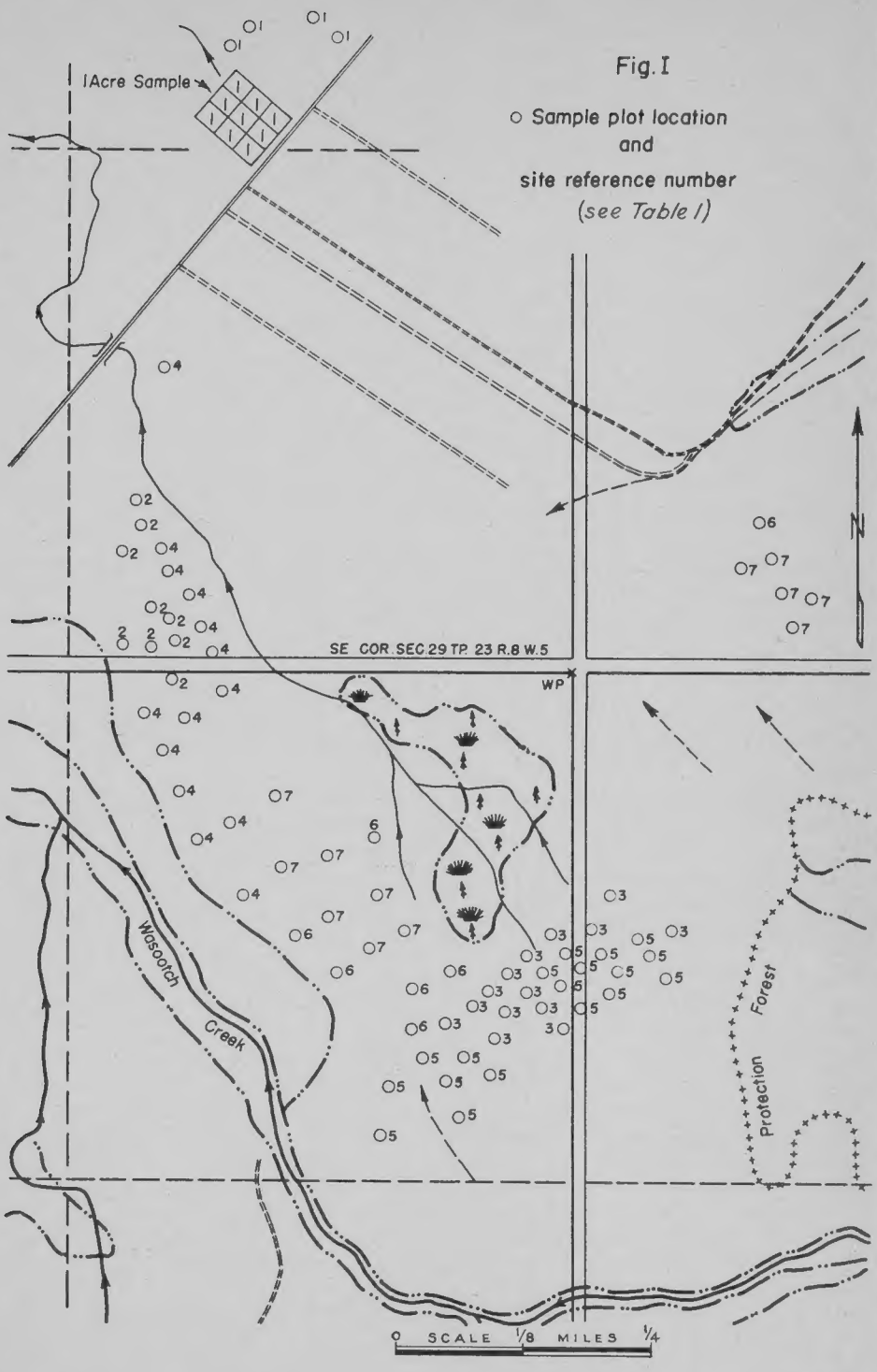
Fig. I
○ Sample plot location and site reference number (see Table I)
1Acre Sample
SE COR. SEC 29 TP 23 R.8 W.5
WP
N
Wasatch Creek
Protection Forest
0 SCALE 1/8 MILES 1/4

annual growth, crowns become uniformly small, and little if any crown differentiation takes place. Since both the original variability in stocking and the tendency to stagnate are not closely associated with site quality, it follows that number of stems per acre at later ages will vary widely within a given site class. Also, because of the high stocking in these stands, the tallest trees in an area are seldom truly dominant and are usually suffering serious competition. Such growing conditions are doubly important because they not only upset the usual behaviour of the tallest trees in the stand but they also seriously influence total cubic foot volume, the customary measure of site productivity. Parker (9), in recognition of these circumstances, carried out a study designed to adjust the growth of dominant trees for variations in stocking, and attempted thereby to produce an acceptable site index. In employing this method of adjustment it has subsequently been found that wide variations in predicted site productivity have been encountered. Therefore the present study was undertaken in 1953 to investigate the basic relationships between site quality, stocking in number of stems per acre, and dominant height.

METHODS

Location of Area

The general area selected for the study lies on the Kananaskis Forest Experiment Station at 51° 00′ N, 115° 10′ W. The station falls within the Subalpine Region as classified by Halliday (3), having a range in elevation from 4,600 feet to 4,900 feet with a general down slope from east to west.

Sampling was confined to undisturbed stands within a single block of the station area. A sketch map (Figure 1) shows the approximate locations of the sample plots. Approximately two thirds of the sample was obtained from areas which were flat to gently sloping and the remaining one third from areas with slopes of from 5 to 20 per cent.

Forest Condition

The forest condition of the area is typical of much of the subalpine forest of Alberta and consists of a pure even-aged stand of lodgepole pine originating from a fire in 1865. Sample ages from dominant trees showed an average at stump height of 80 years plus or minus two, indicating that regeneration of the area took place shortly after the fire. The present appearance of the stand varies greatly due to differences in stocking and site quality. Number of stems per acre in 1953 varied from 700 to 4,000, while average diameter showed a spread from 1·8 inches to 6·1 inches, and average height varied from 20 to 60 feet. As would be expected in a 90-year-old stand with such high stocking, the crowns of the trees tended to be relatively short and narrow and the form class of individual trees was relatively high.

Soils and Sites

During the field season the sampling area was visited by W. G. E. Brown, Forestry Branch site specialist, who studied the physiographic sites of the area and described a series of seven soil conditions which are apparently associated with the variable productivity shown by the forest. Much of the variability of the soils in the sampling area which lies on the lower slope and base of a broad valley formed by the Kananaskis River is accounted for by its geological history. The roughly terraced formation of the sides of the valley suggests a series of lateral moraines, local portions of which were probably washed by mountain streams, removing the fine soil particles. On the lower and more gently sloping area alluvial material accumulated. In still other areas fine silt layers of aeolian

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origin have been laid down to varying depths. This complex nature of soil origin has given rise to the great local variability of physiographic sites on the area.

The system of forest site classification employed was developed by Hills (4). Symbols assigned to the seven soil and moisture conditions described by Brown are shown in Table 1. In each symbol the first number represents position on the 11-unit moisture scale, while the second numeral describes position on a 11-unit scale of permeability. Letters following the numerals indicate origin and fabric of the parent material: A = Aeolian, D = Dumped till, W = Washed till. The subscript S indicates excessive stoniness. The oblique stroke in the permeability and parent material symbols indicates stratification of materials. The symbols A^3, A^2, and A^1 indicate differences in the depth of aeolian material, $A^3 = 18''+$, $A^2 = 6-18''$, $A^1 = 0-6''$, which were obviously characteristic of a difference in site productivity.

TABLE 1

Physiographic Site	Soil Conditions	Site Reference Number
2: 3: A^3/Ds	Well drained deep aeolian silt/stony dumped loamy till	1
2: 3/2: A^3/Ws	Somewhat dry deep aeolian silt/stony washed sandy till	2
2: 3: Ds	Well drained stony dumped loamy till	3
1: 3/2: A^2/Ws	Somewhat dry medium thickness aeolian silt/stony washed sandy till	4
1: 2: Ds	Somewhat dry stony dumped loamy till	5
1: 3/2: A^1/Ws	Somewhat dry shallow aeolian silt/washed sandy till	6
O: 1: Ws	Dry stony washed gravel	7

In Table 1 the physiographic site conditions encountered in the area have been arranged in their expected order of potential productivity based on the amount of available soil moisture, the depth of the fine textured aeolian cap, and the nature of the till material.

The physiographic site No. 1 (2: 3: A^3/Ds) by virtue of its preponderance of fine materials in both the aeolian and till layers, combined with its location on a very gradual slope, should produce the most desirable growth because of favourable rooting qualities and excellent moisture conditions. Site No. 2 (2: 3/2: A^3/Ws) should be next in order of productivity because of the poorer till underlying the fine cap.

Sites 3 (2: 3: Ds) and 5 (1: 2: Ds) both lie at the base of the moderately steep slope of the main Kananaskis mountain range. They are excessively stony to the surface, and this inhibits rooting in comparison to sites with an aeolian cap. The distinction between Sites 3 and 5 is related to topographic position on small valleys and ridges respectively, running down the main slope of the mountain range. As a result, Site No. 3 has a more favourable moisture supply and should be more productive of the two.

Site No. 4 (1: 3/2: A^2/Ws) represents a moderately dry site. The surface layer of fine aeolian material up to 18 inches in depth favours root development and should result in a greater productive capacity than Site No. 5, with the same moisture regime but poorer soil material.

Sites 6 (1: 3/2: A^1/Ws) and 7 (O: 1: Ws) were somewhat similar although the shallow layer of fine material on the surface of Site No. 6 appears to reduce droughtyness to some extent. Site No. 7 is extremely poor as a result of excessive washing which has produced a condition similar to a pile of boulders.

Climate

The second of the major factors influencing the site productivity of an area is the effect of climatic conditions. Within such a small area as that selected for the study it may safely be assumed that variation in regional climate does not exist. However, there is still the effect of local climate modifiers to be considered in particular, warm dessicating winter winds. With this problem in mind the area was investigated by H. Cameron, Meteorologist, Forestry Branch, Ottawa. As a result of his study, Cameron felt that there were no local modifications of climate within the area which might be suspected of causing variations in site productivity.

Stand History

Although history is usually regarded as a major factor in determining the site characteristics, in this study it may be considered of minor importance for two reasons. First, the study is concerned only with potential productivity for a single rotation; and secondly, all parts of the area, as far as can be determined from casual observation, have undergone a similar development. Inasmuch as the present stand shows a uniform condition of pure even-aged lodgepole pine and since the previous mature stand destroyed by fire was of a similar type, it appears that for at least 200 years the history throughout the area has been uniform.

Distribution of Sample

The distribution of the sample was based mainly on the soil conditions established by Brown. Arbitrarily selected plots were established covering the range in number of stems per acre which was found to occur within each physiographic site. The only other limitation placed on the location of the sample plots was that they should be growing at full density with no unoccupied spaces in the canopy. The fact that the plots contained large numbers of stems per acre at an advanced age insured that the stands were growing at full density. For purposes of clarity, the terms stocking and density are given specific meanings in this report. Stocking is used as a descriptive term implying the number of stems per acre, while density indicates the actual basal area of a stand in relation to maximum capacity.

Field Data

A total of 83 single examination sample plots were laid out to provide data for this study. Of these samples, 74 were individually located one-tenth-acre plots. The remaining nine plots consisted of equal subdivisions of a one-acre sample block (Figure 1).

On each sample plot all live trees were tallied by species and one-inch diameter classes. Number of stems and basal area per acre were computed in the field, and average diameter was determined. The heights of 3 to 5 trees whose diameters were within one-tenth inch of the average diameter were measured with the abney level. The five tallest trees per plot were selected and their diameters and heights were measured with diameter tape and abney level. These selected trees were scribed and subsequently a number of them were felled as a check on height measurement accuracy. It was found that the maximum error determined from these checks was plus or minus 1·0 foot. The average diameter and height of the five tallest trees was determined, and the average height of the tree of average diameter per acre was calculated. The approximate volume of each plot was determined by a technique developed by Parker and Holman (8) which involved determining the volume of the tree of average diameter and multiplying this volume by number of stems per acre. Tests of this method have shown maximum error of two per cent in volume for lodgepole pine stands. On the basis of a soil pit or auger hole, the plots were assigned to a physiographic site.

PLATE 1. 90-year-old stand on Site No. 1 (2: 3: A/Ds), 800 stems per acre.

PLATE 2. 90-year-old stand on Site No. 1 (2: 3: A/Ds), 2,000 stems per acre.

PLATE 3.—90-year-old stand on Site No. 1 (2: 3: A/Ds), 5,000 stems per acre.

Method of Analysis

The data gathered consist essentially of descriptions of site features for each plot, together with various measures of the productivity and growth on them. The analysis attempts to show which of the growth factors appear to be dependent on conditions other than site quality. In order to present the data in the simplest possible form, scattergraphs of the individual plot growth data, subdivided by site characteristics, have been plotted.

In attempting to obtain explanations for some of the relationships which appeared to exist, a multiple regression analysis was carried out. The results of this analysis have only served to confirm the relationships shown by the scattergraphs, and because of its limited interest the analysis has not been presented.

PRESENTATION OF DATA

The information gathered in this study has provided data on a large number of variables. Of these, physiographic site, climate, and age may be regarded as independent variables. (Throughout this paper the single term 'site' refers to physiographic site condition.)

Since this stand is truly even-aged, and the local climate conditions are very uniform, the only independent variable of consequence in the study is site.

Of the dependent variables, basal area and total cubic foot volume per acre in fully stocked stands should be the two best direct measures of site productivity. The effect of number of stems per acre, because it appears to exert a considerable influence on growth, should also be investigated. Figures 2 and 3 illustrate the effects of site quality and number of stems per acre on basal area and total volume per acre.

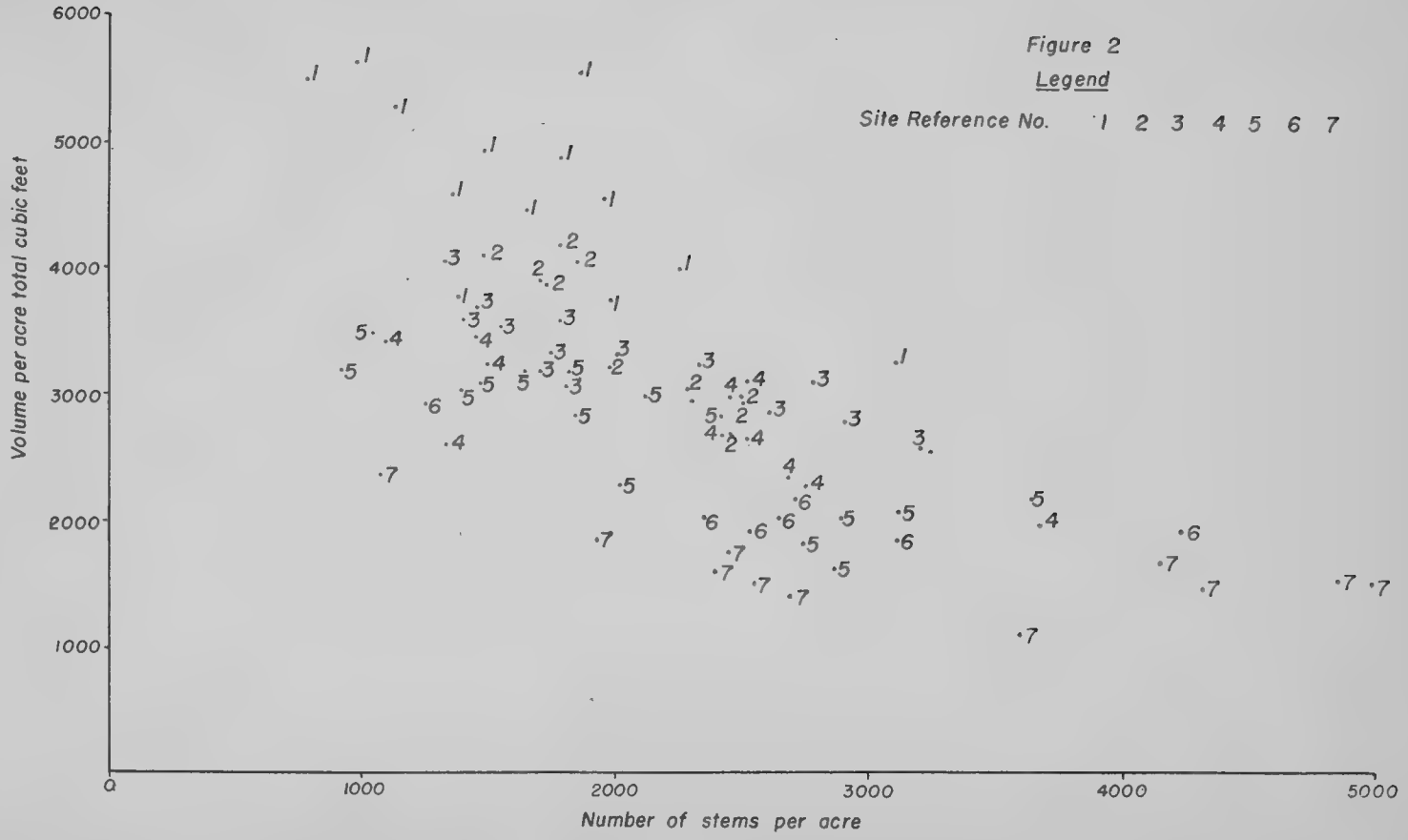

FIGURE 2.—Effect of number of stems on volume per acre by site classes. Numbers on the chart indicate the site quality (site reference number) of individual plots.

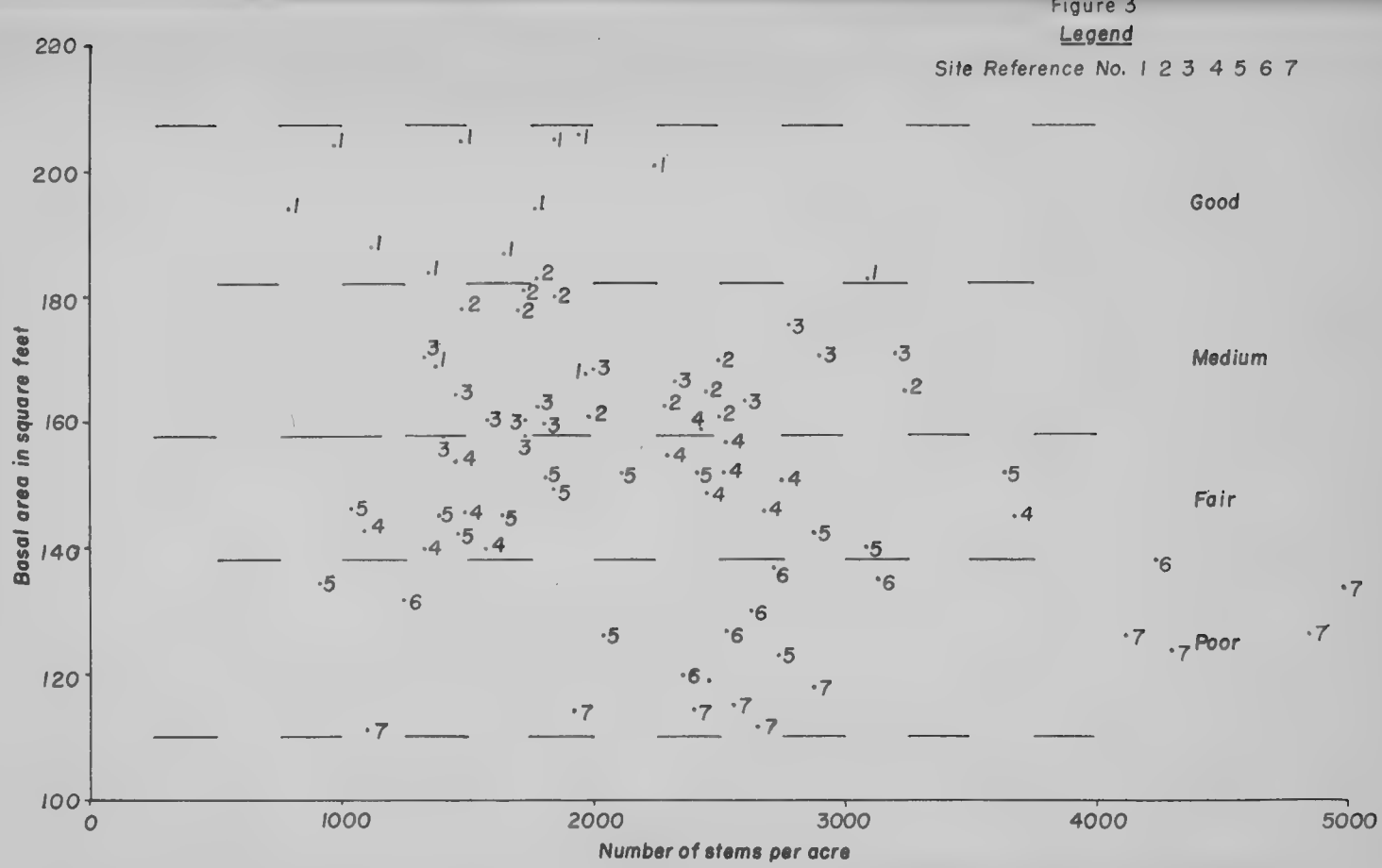

FIGURE 3.—Effect of number of stems on basal area per acre by site classes. Numbers on the chart indicate the site quality (site reference number) of individual plots.

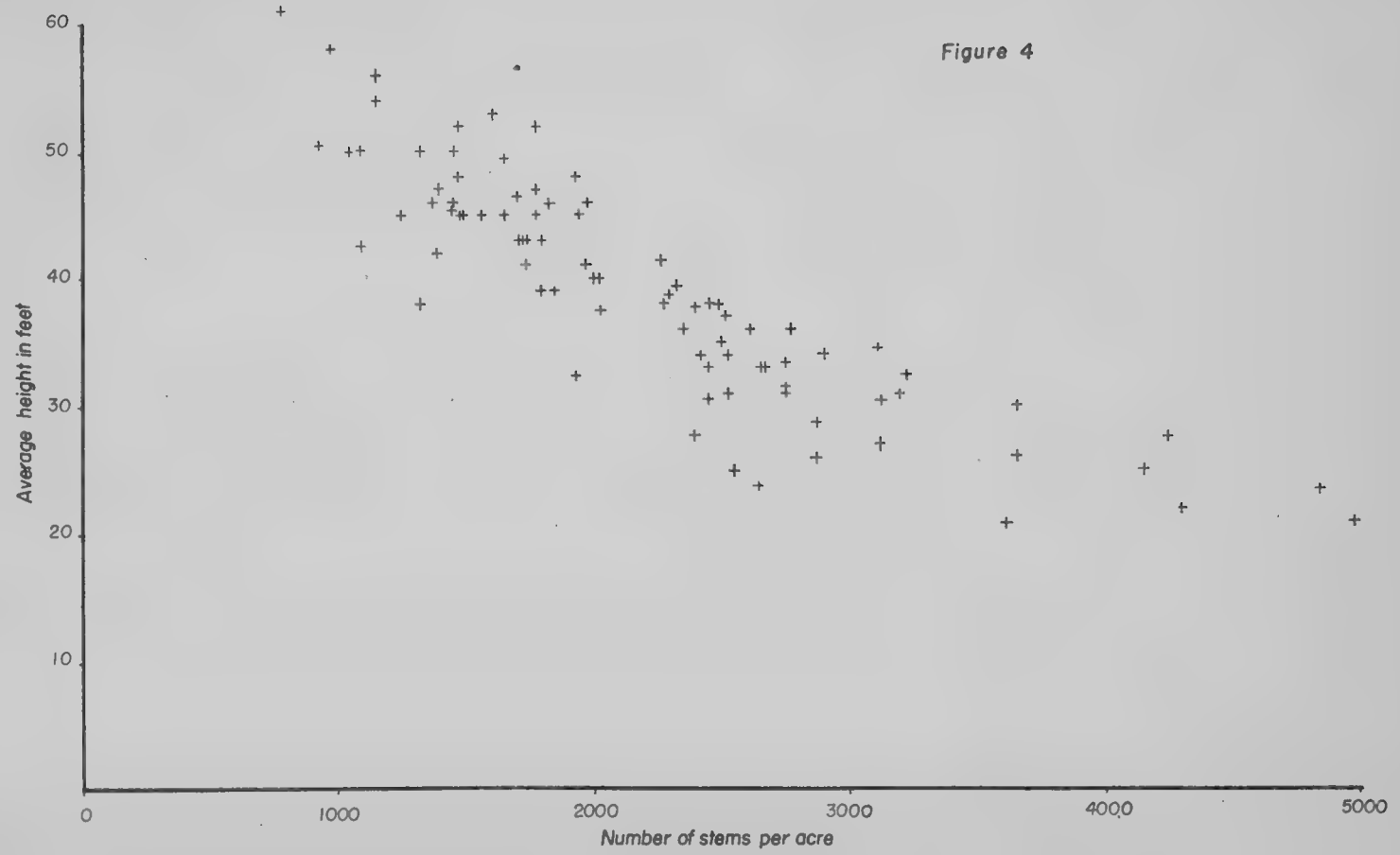

FIGURE 4.—Effect of number of stems on average height.

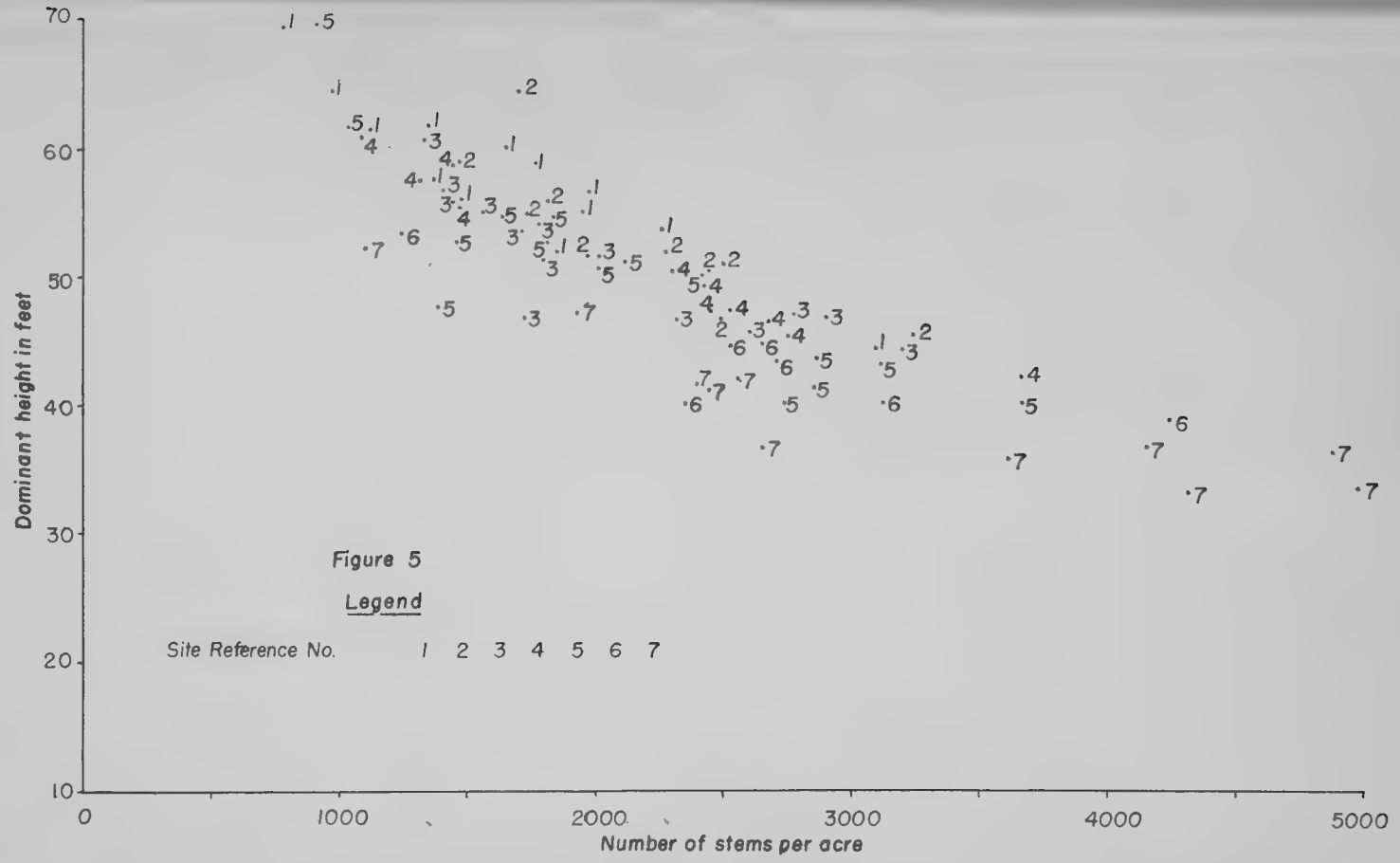

FIGURE 5.– Effect of number of stems on dominant height by site classes. Numbers on the chart indicate the site quality (site reference number) of individual plots.

The relationship of total volume per acre to number of trees per acre by site quality classes, shown in Figure 2, exhibits several points. Regardless of the different site conditions, there appears to be a definite trend towards decreasing volume per acre with increasing number of stems. However, at the same time there does not appear to be any strong relationship between physiographic site and stocking; the variability in number of stems per acre on each of the sites is very great, and approximately the same range in number of stems can be found on each of the sites. Neither is there any strong stratification of the volumes with relation to the site. It is true that the driest sites generally have the lowest volumes, and the wettest sites have the highest volumes, but the mixing of the volumes on the various sites indicates no possibility of assigning site productivity values based on volume.

In Figure 3, basal area per acre in relation to number of trees has been plotted by physiographic sites. In contrast to Figure 2, there is no evidence of any well-defined relationship between basal area per acre in full density stands and number of trees per acre. At the same time the basal area data are moderately well sorted by site; this tendency becomes more evident when the data are divided into four broad classes of productivity. The highest band, 182 or more square feet, contains only Site No. 1. The second or medium band contains two sites, No. 2 and No. 3. The third basal area class contains plots from Sites 4 and 5. The fourth and lowest band of basal area, 110-138 square feet, contains plots from Sites 6 and 7. Three plots from Site No. 5 are also present in this lowest group. Later re-examination suggested that an incorrect moisture rating had been assigned to them originally, which would account for the reduction in yield.

A comparison of Figures 2 and 3 illustrates some of the rather unique characteristics of lodgepole pine growth. If physiographic site is the principal factor influencing the productive capacity in fully stocked stands, basal area and total volume per acre might be expected to group in accordance with productive capacity. However, in the case of volume, this did not occur. Total cubic foot volume may be loosely described as a function of basal area per acre and average height of the stand. However, average height values from the plots shown in relation to number of stems per acre in Figure 4 demonstrate a strong relationship between these two factors, which is relatively independent of site. Thus, total volume per acre depends on two factors: basal area per acre, which is closely related to site and relatively unaffected by number of stems per acre, and average height, which is closely related to number of stems per acre and shows little effect due to site. Consequently, productive capacity as expressed by total cubic foot volume, dependent upon both basal area and average height, bears only a weak relationship to the physiographic site.

Because of the widespread use of dominant height as an index of site productivity, it is of interest to analyse the dominant height relationships of this set of data. The values have been plotted using the same site symbols as in the previous illustrations. Figure 5 shows the effect of number of stems per acre and site on dominant height. The tendency towards decreased height with increasing numbers of stems, plus the relatively limited scatter of the data, indicates the strong relationship between dominant height and number of stems per acre. Although there is some tendency for the data to be sorted by sites, this sorting is so weak that it is quite apparent that the relationship of dominant height to physiographic site is almost negligible.

Since physiographic sites cannot be expressed quantitatively, basal area per acre figures have been substituted for them and the data have been replotted in Figure 6 by classes based on number of stems. This step has been considered justifiable in view of the fact that basal area is both a measure of productivity and

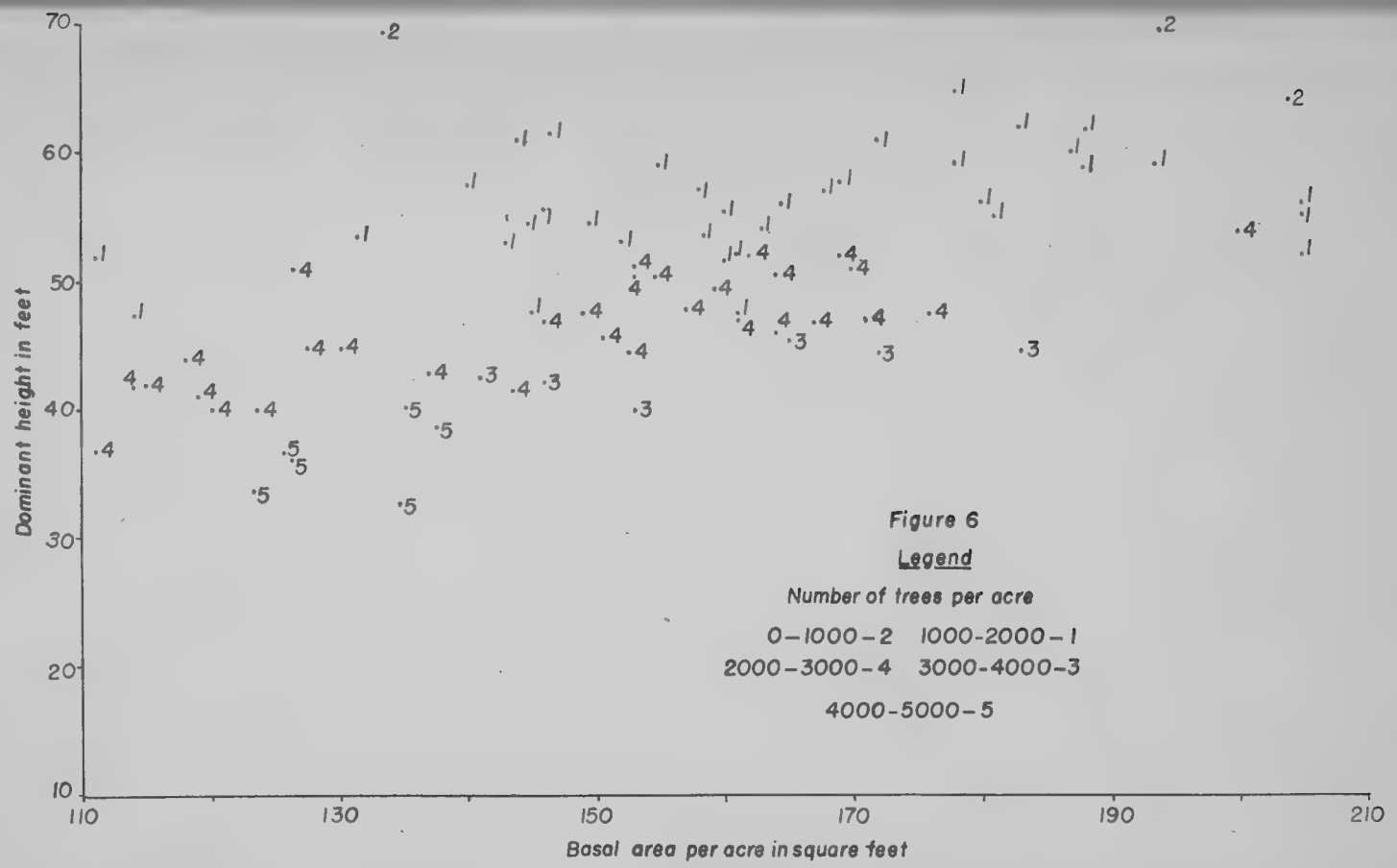

FIGURE 6.— Relationship of dominant height to basal area per acre by number of stems. Numbers on the chart indicate the site quality (site reference number) of individual plots.

at the same time, as has been shown by Figure 3, is strongly related to physiographic site. Figure 6 demonstrates the extremely weak relationship which exists between dominant height and site productivity as expressed by basal area. However, the obvious stratification of the data again shows the strong effect of number of stems on dominant height.

As mentioned previously, nine of the sample plots consisted of equal subdivisions of a one-acre sample area. This acre was selected because of its uniform site conditions as indicated by a series of soil pits. It is located at the western edge of a long gently-sloping terrace extending for approximately one mile in an easterly direction. The soil condition was described as Site No. 1 (2: 3: A/Ds) and the stand showed a gradual decrease in stocking from the east to the west side of the plot. On each of the nine subdivisions, data on basal area, volume, number of stems, average diameter and height, and dominant height were obtained and are presented in Table 2.

TABLE 2.—STAND DATA PER ACRE (1953)

Sub Plot No.	Basal Area	Number of Stems	Total Volume Cubic Feet	Average Height	Dominant Height
1	182·5	3,102	3,260	39·5	44·6
2	200·5	2,266	3,988	41·5	53·9
3	205·8	1,950	4,524	45·0	55·2
4	205·4	1,848	5,529	48·0	52·0
5	193·5	1,770	4,868	52·0	59·0
6	205·0	1,480	4,914	52·0	56·2
7	188·1	1,120	5,268	54·0	61·6
8	204·2	980	5,613	58·0	64·6
9	194·0	783	5,487	61·0	69·5

When the data are arranged in descending order of number of stems per acre as in Table 2, it is interesting to note the remarkable uniformity of the basal area per acre in comparison with the 74 one-tenth-acre samples which ranged from 110 to 200 square feet. Basal area shows no apparent effect from number of stems, and seems to be reacting purely to the uniformity of the site. On the other hand, average height and, to a somewhat lesser extent, volume per acre show the strong effects of decreasing number of stems. Dominant height likewise shows the influence of number of stems per acre, since a 25-foot range in the dominant height values results from the variation in the number of stems per acre. It is interesting to note that in an adjacent area on the same site, individual free-growing dominant trees of 12 inches d.b.h. gave height values of 80 feet, suggesting that even at 783 trees per acre, as in subplot 9, Table 2, the stand may be regarded as seriously overcrowded.

DISCUSSION

Several relationships which are not consistent with the yield table data of other native Canadian species have been illustrated. Before drawing any conclusions as to the usefulness of various site indices when dealing with lodgepole pine, some explanation of the unusual behaviour of this species is necessary.

In studies of growth and development of the majority of native species, the number of stems per acre in stands approaching maturity is strongly correlated with the site quality and productivity of the stand. However, in this sample of lodgepole pine data, the change in basal area productivity and physiographic site was not accompanied by a corresponding change in number of stems per acre; and at the same time, the range in number of stems per acre at any basal area level or on a given site was extremely high.

One explanation for the unusual behaviour of these lodgepole pine stands may be obtained by comparing the development of such stands with those of other better understood species. For example, the eastern pines and associated species generally show relatively low stocking figures in juvenile stands with rarely more than 10,000 well-established seedlings occurring per acre. In contrast, it is not impossible to find 10-year-old lodgepole pine stands supporting half a million well-established seedlings per acre. However, at the same time, poorly stocked lodgepole pine stands often occur. This wide variation in stocking does not appear to show any degree of dependency on the site productivity factors, and probably is a function of the intensity of the fire from which the stand originated, the available seed supply, and a host of other minor factors. Studies by Horton (6) tend to confirm this chance variation in the stocking of lodgepole pine stands.

For most species, rapid crown differentiation takes place and from the earliest years there is intense competition for nutrients, moisture, and light among the individual trees, with the most thrifty individuals becoming dominant and the weakest stems dying. Generally, competition is keenest and crown differentiation greatest on the most highly productive sites. As a consequence the number of stems in semi-mature and mature stands is closely correlated with the site productivity, while at the same time the initial low stocking and rapid mortality greatly reduce the variability in numbers of stems.

In contrast, dense lodgepole pine stands show extremely poor crown differentiation, and even the least thrifty individuals are able to maintain a limited growing space in the stand; in effect the stands stagnate. In consequence, the initial variability of stocking, which apparently is not related to site productivity, is modified very little as the stands approach maturity.

This set of data has indicated that most of the growth factors including volume, average height and dominant height, as well as average diameter, are strongly influenced by the number of stems per acre, regardless of the physiographic site on which the stands occurs.

Basal area appears to represent the one exception to this tendency. Regardless of the number of stems per acre, the basal area in mature fully-stocked stands shows definite indications that it is pre-determined by the physiographic characteristics of the site. Part of the explanation for this behaviour lies in the typical basal area development of intolerant pine stands. It has been indicated by permanent sample plot studies of various intolerant pines (Meyer 7; Smithers 10, 11) that basal area in fully-stocked stands increases rapidly during the first 40 years of stand development; culmination of this curve then takes place and the stand basal area continues at a relatively uniform level consistent with the site quality, showing only minor fluctuations until the stand becomes fully mature. This level appears to be reached in spite of considerable fluctuation in the number of stems per acre, provided the stands contain enough trees to fully occupy the site. Furthermore, in the case of thinned stands, where heavy removals of basal area have taken place, the stand, after treatment, increases its basal area until it returns to its site quality level and then remains relatively constant. It appears that any physiographic site can supply only sufficient nutrients and moisture to support a given amount of basal area, and increases over this amount must be compensated for by mortality.

The effect of number of stems per acre on the height development of lodgepole pine stands is very pronounced. Average height based on height of trees of average diameter shows a very strong relationship with number of stems per acre, and little if any relationship with physiographic site. This relationship is reflected in the volume data as has been mentioned previously. Dominant height is similarly affected. In heavily overstocked lodgepole pine stands all

of the trees are suffering serious competition and no tree is growing freely; consequently, height-growth of the dominant trees behaves abnormally. This relationship has been observed by Craib (2) in working with black wattle and various exotic pines planted in South Africa, and by Parker (9) who attempted to provide a solution by adjusting for variability in numbers of stems per acre using a multiple regression relationship. Further attempts to employ Parker's method have shown that the results are too erratic to provide a satisfactory solution to the problem. A further examination of the relationships shown in Figure 6 indicates the reasons for the failure of this method. These dominant height values showed an extreme range of 37 feet associated with a range of 100 square feet of basal area. Variability in dominant height caused by differences in the number of stems per acre at a given basal area level is approximately 22 feet. Therefore, there is only a 15-foot range in dominant height to be associated with the full range of site productivity. When the variations arising from genetic factors and instrument limitations are considered, it would appear quite impossible to subdivide this 15-foot range into an adequate number of site productivity classes.

The use of ground cover species as indicators of forest site quality has received considerable attention in various forest regions of Canada. Holman and Parker (5) carried out a study in lodgepole pine stands to determine the relationship of ground cover plants to various measures of stand productivity. As a result of this study, they found that the forest plants commonly found in lodgepole pine stands in Alberta were more closely associated with the stocking of the stand than they were with site conditions as indicated by stand productivity, and consequently would be of limited value as an index of site quality.

CONCLUSIONS

Any site index, in order to be classed as satisfactory for growth and yield studies, must fulfill certain definite requirements. It should be relatively easy to measure in terms of time required and skill necessary. It must be capable of providing an estimate of the growth potential for both individual sample plots and also larger working areas such as sub-compartments. It must also be independent of the effects of variation in stocking due both to natural variability and also to changes brought about by cultural practices such as thinning. Such an index must also be applicable in stands of varying ages and must provide a basis for comparison of stands of different ages.

It has been pointed out in the preceding section of this report that, because of the unusual behaviour of dense lodgepole pine stands, it would be undesirable to employ either dominant height or ground cover plants in the customary manner as indices of site productivity. Even when attempts are made to eliminate the variability in dominant height caused by changes in number of stems per acre, the results are unsatisfactory.

Because of the apparent close relationship between basal area per acre and site irrespective of variations in number of stems per acre, it has been suggested that basal area might be employed as a site index. However, in addition to being cumbersome to measure, such an index would be valid only in stands which are heavily stocked and growing at full density. In addition, basal area would be of very little value in young stands of less than 50 years of age in which the basal area had not reached full density. It does appear however that basal area can be used in conjunction with the development of a physiographic site classification. One of the major problems in such a classification is the sorting and combining of various sites into classes having similar productive capacities. It is suggested that if preliminary physiographic site studies are carried out in

fully-stocked mature stands, the sorting may be done on a productivity basis of basal area per acre, and the study may then be safely extended by means of physiographic conditions to stands which are immature or understocked.

It would therefore appear that the problem of classification of site quality in lodgepole pine stands in Alberta may best be solved by an application of the principles of physiographic site classification as set out by Hills (4) and Brown (1). Not only does this method appear to be closely related to potential productivity of the forest stands, but also it is applicable under a wide variety of forested and non-forested conditions. Such a method may be employed to define site quality with any degree of exactness required by the forester, including the broad mapping of forest sites from air photographs.

Although the primary purpose of this report has been to assess the effect of stocking on various site indices, it has become increasingly evident that number of stems per acre exerts an important influence on all phases of growth in lodgepole pine stands. It is suggested therefore that number of stems per acre must be employed as a primary variable in the construction of yield tables and in the gathering of forest inventory information.

SUMMARY

Because of difficulties encountered in trying to estimate forest site productivity in dense even-aged stands of lodgepole pine in the subalpine region of Alberta, a study was undertaken to investigate the value of various site indices now in use. For simplicity, the observations were confined to a single, pure, even-aged stand of 90-year-old lodgepole pine, on an area where climatic variation was at a minimum. Within this area, physiographic site was the major feature in determining productivity. Types of physiographic sites were sampled by means of one-tenth-acre plots to assess the variation in growing conditions which occurred in the forest. In addition to classifying physiographic sites, observations were made of the basal area, volume and number of stems per acre, as well as the dominant height and average of dominant trees on each sample plot.

The relationships between these variables were analyzed by graphic techniques. The results showed that site indices currently employed including total volume, average height, dominant height and adjusted dominant height, cannot provide a valid estimate of site productivity because of the undue influence of number of stems per acre which exhibits large chance variability. A productivity grouping based on a classification of physiographic characteristics was associated with relatively constant levels of basal area regardless of the number of trees present in dense stands. Because of its wide applicability and its freedom from extraneous influence, a productivity rating derived from the physiographic characteristics of the site appears to be the best type for use in dense lodgepole pine stands.

DATE DUE SLIP

DUE CAM APR 20'79
FEB 2 5 '88
MAR 0 3
0 1 '80
MAR 24 80
NOV 13 '80
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MAR 3 1 RETURN
DUE CAM APR 10'85
APR 03 RETURN
DUE CAM APR 30 '86
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NOV 19 RETURN
DUE CAM MAR 14'87
Due Cam MAR 22'94
MAR 0 8 RETURN
DUE CAM JUL 02'87
JUN 23
RETURN NOV 26 '95
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